THE GENUS *MILTHA* (MOLLUSCA: BIVALVIA) IN THE AUSTRALIAN CAINOZOIC

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SUMMARY

The rare genus *Miltha* is well represented in southern Australia in limestones and sandstones of Miocene to Pleistocene age. Five species are present: *Miltha nullarborensis* Ludbrook sp. nov. in the Nullarbor Limestone (Lower Miocene), *M. dennanti* Wilkins in the Upper Miocene to Lower Pliocene formations of Victoria and South Australia, *M. flindersiana* Singleton and Woods in the Upper Pliocene of South Australia and Flinders Island, *M. lindsayi* Ludbrook sp. nov. in the Upper Pliocene of South Australia and *M. hamptonensis* Ludbrook sp. nov. in the Pleistocene of the Eucla Basin.

The genus lives at present off the southern coast of California and off the coast of Brazil in latitudes 8°-23°; Cainozoic occurrences are nearly all between latitudes 30° and 40°.

INTRODUCTION

Miltha is a genus of large disc-like lucinid bivalves with a restricted geographical distribution and very limited specific differentiation. Some thirteen species, most of which are represented by a few individuals, can be assigned to the genus in the strict sense. Only two are known to be living today—*Miltha childrenae* (Gray) from Brazil and *M. xantusi* (Dall) from Baja California. With two possible exceptions, one in the Paleocene of New Zealand and the other in the Californian Eocene, the genus first appears in the late Oligocene or Miocene of California, Florida, Argentina, New Zealand and Australia. Despite the paucity of specimens, *Miltha* is well represented in southern Australia from the Miocene to the Pleistocene.

Material used in the present study is in the collections of the Geological Survey of South Australia (GSSA), National Museum of Victoria (NMV), Geological Survey of Western Australia (GSWA), and the Western Australian Museum (WAM). I wish to thank the Director of Mines South Australia, the Director and Mr. T. A. Darragh of the National Museum of Victoria, the Director Geological Survey of Western Australia, and the Director and Dr. D. Merrilees of the Western Australian Museum for making it available. I am grateful also to Dr. A. G. Beu of the New Zealand Geological Survey for information on the New Zealand distribution of *Miltha*.

GENERIC CHARACTERS

The shell of *Miltha* in the strict sense is usually a large, slightly convex disc 70 mm. or more in diameter with a well developed posterior area separated from the rest of the shell by a radial ridge and slight flexure; the anterior area is relatively poorly defined by a shallow sulcus; the lunule is small, impressed, and tending to encroach upon the cardinal area; the ligament is long and sunken below the dorsal border; there are two cardinal teeth in each valve—3a and 3b in the right and 4b and 2a in the left—but no laterals. The posterior adductor is more or less oval, the anterior adductor long, extending nearly halfway across the shell adjacent to the pallial line.

The subgenus *Milthoidea* was erected by Marwick (1931), relying on Reeve's (1841) figure of *Lucina childreni* (*sic*) Gray, and with *Miltha neozelanica* Marshall & Murdoch as the type species, for forms having the posterior wing well developed, the long anterior muscular impression adjacent to the pallial line, the lunule small, deeply excavated and tending to obliterate the right anterior cardinal, and the attachment for the ligament broadly triangular. As *Miltha* has all of these characters, Chavan (1938) considered that *Milthoidea* should be synonymized with *Miltha*, with which I have previously expressed agreement (Ludbrook, 1955). The original material of the type species *Lucina childrenae* Gray has now been located in the Cracherode Shell Collection of the British Museum (Natural History) and the lectotype, Crach. No. 216, figured (Wilkins, 1957). Any doubts as to the nature of the shell characters which might have justified the subgenus are removed.

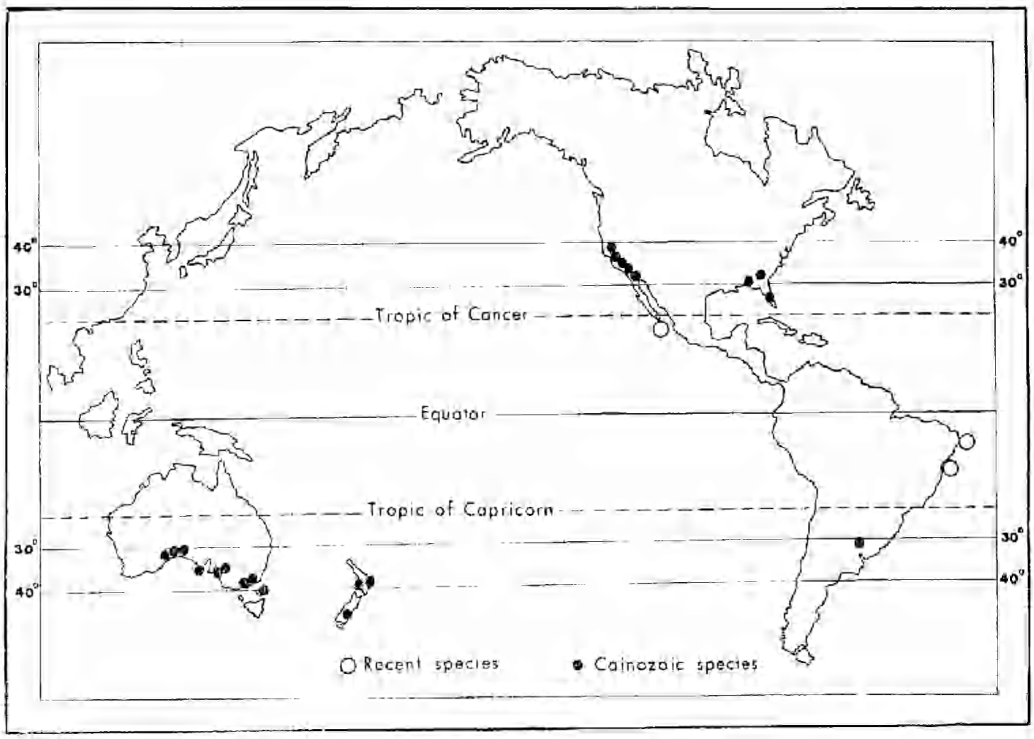

Fig. 1. Distribution of *Miltha*.

DISTRIBUTION

Fossil and living records of the genus are shown in Figure 1. With two exceptions they date from the late Oligocene or from the Miocene when it became well established in the Americas and in Australia and New Zealand.

Although the fragmentary nature of the material renders its location in the genus open to some doubt, the earliest record of *Miltha* is that of a small species, *M. agilis* Finlay & Marwick from the Wangaloa fauna (Paleocene) of New Zealand. According to Beu (1966) the genus then continues to the end of the Pliocene in New Zealand. Dr. Beu (in correspondence) has given the following ranges for the species: *M. agilis* Wangaloa fauna only; *M. dosiniformis* Marshall

and Murdoch Whaingaroan (early Oligocene) to Tongaporutuan (Upper Miocene) almost continuous; *M. neozelanica* Marshall & Murdoch Waitakian (late Oligocene or basal Miocene) to Waipipian (mid-Pliocene), rare, discontinuous, common only in Waipipian.

The genus is represented in the Eocene of California by *Lucina packi* Dickerson, placed in *Miltha* by Vokes (1939). From the Miocene to Pliocene it occurs in several formations in southern California (Grant & Gale, 1931), including the Temblor (Vaqueros of Arnold, 1909) Formation and the Monterey Shale (Woodring, Bramlette & Kew, 1946). The Miocene *M. sanctaecrucis* Arnold was placed in synonymy with the Pliocene—Recent *M. xantusi* (Dall) by Grant & Gale, but not by later authors. From the figures the two appear to be distinct, *M. sanctaecrucis* being more circular in outline like the Australian *M. flindersiana* and *M. hauptonensis*.

In Florida the Miocene-Pliocene record of *Miltha* is similar to that of California with *M. chipolana* (Dall) in the Chipola Formation and Oak Grove Sand of the Alum Bluff Group (Dall, 1903; Gardner, 1926) and *M. caloosaensis* (Dall) in the Pliocene Caloosahatchie Formation.

In South America *Miltha iheringiana* Doello-Jurado was described from the Miocene of Entre Rios, Argentina.

The record in Australia is also somewhat sporadic, with a maximum development in the Pliocene.

All Cainozoic occurrences except the Wangaloan *M. agilis* in the South Island of New Zealand and the Caloosahatchie *M. caloosaensis* of Florida lie between latitudes 30° and 40°.

The two Recent species *M. childrenae* (Gray) and *M. xantusi* (Dall) are notable for their rarity. *M. childrenae* occurs off the Brazilian coast between latitudes 8° and 15°; it has been recorded from Recife (Pernambuco) and Salvador (Bahia). *M. xantusi* has been described as "one of the rarest as well as next to the largest of the West American lucines . . . known only by a few specimens, most of those taken off Cape San Lucas in depths of 30 or more fathoms" (Keen, 1958). The locality is approximately at 23° N.

The present surface temperature requirements of the genus appear to be within the range of 21° C. and 27° C., those of Cape San Lucas being February 21° August 27°, and of Brazil August 23° February 27° (Sverdrup, Johnson & Fleming, 1942, Charts II and III).

Discussions of the genus and its distribution are contained in Chavan (1938), Dall (1903, 1905), Gardner (1926), Keen (1958), Lamy (1920) with a synonymy of *M. childrenae*, Stewart (1930). Species from the European Eocene previously placed in *Miltha*, as well as *Lucina voorhoevei* Deshayes from Mozambique, doubtfully referred to *Miltha*, and several American species are now placed in such genera as *Eomiltha* and *Recticardo*.

AUSTRALIAN OCCURRENCES

Miltha was first recognized in Australia by Tate (1890) from fragments recovered from Dry Creek Bore. Fragments from Abattoirs Bore were subsequently described by N. H. Woods (1931) as *Dosinia grandis* (*non* Nelson, 1870), and later as *Miltha* (*Miltholdea*) *grandis* by Singleton & Woods (1934). An incomplete specimen from Flinders Island, Tasmania, "probably conspecific with the South Australian specimens" was separated as a subspecies *M.* (*M.*) *grandis flindersiana* Singleton & Woods. Cotton (1947) renamed the species *Milthoidea hora* (*nom. nov.* for *Dosinia grandis* Woods 1931 *non* Nelson, 1870), the species being relocated in *Miltha* by Ludbrook (1955, 1959).

The collection of further material from Flinders Island and from Gippsland, Victoria, enabled Wilkins (1962) to extend the geographical range and the speciation of the genus. The Flinders Island subspecies was raised to specific rank and an internal mould and cast from Mitchell River, Gippsland, described as a subspecies *Miltha flindersiana dennanti*.

Miltha is now known to occur in the Lower Miocene Nullarbor Limestone, to be well represented in the Pliocene of the St. Vincent and Murray Basins of South Australia and to survive to the Pleistocene of the Eucla Basin. Five species having stratigraphic utility are recognized: *Miltha nullarborensis* Ludbrook sp. nov. in the Nullarbor Limestone; *M. dennanti* Wilkins in the Mitchellian (Upper Miocene) of Gippsland, the Cheltenhamian Black Rock Sands and the Bookpurnong Beds (Lower Pliocene); *M. flindersiana* Singleton & Woods, the name on elevation to specific rank having priority over *M. hora*, in the Upper Pliocene of the Cameron Inlet Formation of Flinders Island, the Dry Creek Sands and the Norwest Bend Formation; *M. lindsayi* Ludbrook sp. nov. in the Norwest Bend Formation, the Dry Creek Sands and the Hallett Cove Sandstone; and *M. hamptonensis* Ludbrook sp. nov. in the Pleistocene calcareous sandstones of the Eucla Basin. All occurrences are in limestones, sandy limestones, quartz sands or sandstones, the best preserved specimens being in incoherent sands such as the Dry Creek Sands or the glauconitic sands of the Bookpurnong Beds. As almost all the well preserved specimens from South Australia occur in subsurface material recovered by percussion drilling, complete specimens are rare. Material from the Nullarbor Limestone and from limestones of the Norwest Bend Formation is always in the form of moulds and casts.

The present surface temperature requirements of *Miltha* and other genera with which it is associated in the Nullarbor Limestone and several of the Pliocene formations give confirmation to the frequently stated observations (e.g. Crespin, 1950; Ludbrook, 1954) that at certain times waters have been warmer in the Flindersian Province of southern Australia than they are today. The genus seems to have established itself in the Lower Miocene at a time when, without allowing for possible differences between water temperatures and palaeotemperatures (Dorman, 1966), water temperatures were in the vicinity of 23-25° and limestones carrying Indo-Pacific foraminifera were deposited.

During the Pliocene, the waters of the Flindersian Province in the restricted sense of Bennett and Pope (1953), that is, the coast of South Australia and the south coast of Western Australia, partly equivalent to Crespin's (1950) Austral Indo-Pacific Province, were probably warmer than those of the Maugean Province of Bennett and Pope (Bass Strait Province of Crespin), since large pearl shells (*Pinctada*) and *Anodontia* are associated with *Miltha* in the Bookpurnong Beds and the Dry Creek Sands. The westward retreat of *Miltha* to survive in the Pleistocene of the Roe Plain is not perhaps anomalous in view of the higher summer surface temperatures of the Great Australian Bight (20°) as compared with Bass Strait (16°) at the present time. Except for the Roe Plain occurrence, *Miltha* did not survive the cooling of waters at the end of the Pliocene. Its association with *Pinctada* suggests that it lived in the South Australian Pliocene at depths of 10 to 40 fathoms or more, comparable with the present habitat of *M. xantusi*.

None of the specimens from Victoria or Flinders Island reach the size of the South Australian and Western Australian forms. This is interpreted as confirming that the waters of the Maugean ("Bass Strait") Province were cooler than those of the Flindersian ("Austral Indo-Pacific") Province in Tertiary as well as in Recent times.

SYSTEMATIC DESCRIPTIONS

Genus MILTHA H. & A. Adams, 1857

Type species (monotypy) *Lucina childrenae* Gray

Miltha dennanti Wilkins

pl. 1, figs. 1-6

1962. *Miltha flindersiana dennanti* Wilkins, 43, pl. 5, figs. 3, 4

Shell large, solid, convex, slightly inequilateral, about as long as high, subcircular, posterior margin truncated, nearly straight, anterior and ventral margins rounded, posterior area well developed and marked by a radial sulcus and slight flexure; umbos small, slightly incurved, prosogyrous, situated slightly to the anterior, lunule small, deeply impressed and extending over part of the anterior cardinal, ligament deeply sunken below the dorsal margin; surface ornamented with numerous concentric threads and obscure radial striae visible in oblique light, concave anteriorly, more conspicuous in the lower half of the shell in the posterior one-third and obsolete elsewhere; between the concentric threads there are numerous microscopic radial striae; a weak shallow radial sulcus concave towards the anterior over which the concentric threads tend to become irregular.

Hinge plate fairly straight, wide, right valve with a small narrow anterior cardinal and a curved posterior cardinal; left valve with a strong triangular broadly grooved anterior and a long, narrow, curved posterior cardinal; resilium area long, fairly broad, triangular; posterior adductor oval, anterior adductor long, parallel to the pallial line on the lower edge and nearly straight on the upper edge, a small deep pedal retractor pit just above the anterior adductor; area within the pallial line thickened with a deposit of secondary calcite divided by a high umbonal-posterior ridge and a furrow extending from about the middle of the ridge to the lower part of the anterior adductor, area below the furrow pitted more strongly than elsewhere.

Dimensions: Hypotypes in the Geological Survey of South Australia Collection vary in length from 74 to 85 mm., in height from 73 to 84 mm., inflation from 15 to 20 mm. (single valve).

Type locality: Bellevue, Mitchell River, Victoria; Mitchellian.

Material: Casts of the holotype NMV P22320-1; 44 specimens: NMV P22801-40 Bentleigh, Victoria; GSSA M1340, M2762, M2774a,b.

Distribution: Mitchellian of Bellevue, Mitchell River; Black Rock Sands (Cheltenhamian); Bookpurnong Beds (Cheltenhamian); Upper Miocene to Lower Pliocene.

Miltha flindersiana Singleton & Woods

pl. 2, figs. 1-6

1931. *Dosinia grandis* N. H. Woods, 148, pl. 7, figs. 5,6 (*non* Nelson, 1870).
1934. *Miltha* (*Milthoidea*) *grandis*; Singleton & Woods, 208, pl. VIII, figs. 1-3.
1934. *Miltha* (*Milthoidea*) *grandis flindersiana* Singleton & Woods, 210, pl. VIII, fig. 4.
1938. *Miltha grandis*; Chavan, 230.
1947. *Milthoidea hora* Cotton, *nom. nov.* for *Dosinia grandis* Woods *non* Nelson.
1955. *Miltha hora* (Cotton); Ludbrook, 53; 1959, Ludbrook, 220.
1962. *Miltha flindersiana*; Wilkins, 43, pl. 5, figs. 1,2.

In describing *M. flindersiana* from a single worn valve from a bore on Flinders Island, Singleton and Woods recognized that it was probably conspecific with the South Australian Pliocene shell originally described as *Dosinia grandis*, and that the differences were perhaps partly due to age. Ludbrook (1955) considered a juvenile from Hindmarsh Bore conspecific with the Flinders Island holotype of *M.* (*M.*) *grandis flindersiana* "probably also a juvenile". The range of specimens now available from Flinders Island and from the Dry Creek Sands clearly demonstrates that *M. flindersiana* is conspecific with *M. hora* over which it has nomenclatural priority. The Flinders Island specimens apparently never grew to the size of adults from South Australia.

The species was fully described by Singleton and Woods (1934). It may be distinguished from other species by its more circular shape, its finer ornament and the flatness of the disc.

Type locality: No. 1 Bore, Wingaroo, Flinders Island, Tasmania, 55-80 feet (16·7-24·3 m.), ?Upper Pliocene.

Material: 3 pairs and 16 valves from dam excavations on Furneaux Estate, NMV P26886, P26887; 6 valves and 7 fragments from bores in the metropolitan area Adelaide, GSSA M304-7, M2227, M3197, M3201,3203; 7 internal casts and moulds from Fishery Bay and Ramco GSSA M3203,3204,3209. Internal casts from Fishery Bay, Eyre Peninsula, hundred of Sleaford, section 11, are all flat, and so far as can be determined in the absence of external moulds, belong to *M. flindersiana*. Internal moulds on limestone of the Norwest Bend Formation at Ramco appear also to be *M. flindersiana*.

Distribution: Upper Pliocene of the Cameron Inlet Formation, Flinders Island, Tasmania; of the Dry Creek Sands, St. Vincent Basin, and of the Norwest Bend Formation, Murray Basin, and sandy limestones of Fishery Bay.

Miltha hamptonensis Ludbrook sp. nov.

pl. 3, figs. 1-3; pl. 4, figs. 1,2

Shell large, thick, nearly circular in outline, slightly inequilateral, left valve slightly convex, right valve nearly flat, both posterior and anterior margins rounded, the anterior more so than the posterior; posterior area poorly developed, narrow, and marked by a very slight flexure; umbos small, sharp, prosogyrous, situated a little to the anterior, lunule deeply impressed and thinly transgressive over the hinge area, ligament deeply sunken below the dorsal margin; surface ornamented with concentric lamellae 2 mm. apart with smooth interspaces but for occasional fine concentric striae. There is a shallow curved radial sulcus and corresponding flexure in the ventral margin of the left valve, in the right valve it is a slight radial ridge and flexure.

Hinge plate relatively narrow, somewhat irregularly curved, with a long thin posterior cardinal and high grooved anterior cardinal in the left valve, a high grooved posterior cardinal and small narrow anterior cardinal in the right valve; resilium area long, narrow, deep; posterior adductor oval, anterior adductor long, well separated from the pallial line; pedal retractor confluent with the anterior adductor; area within the pallial line moderately thickened, a high subumbonal-posterior ridge and a short anterior ridge below the hinge plate, a weak furrow from the middle of the posterior ridge to the lower part of the anterior adductor. Inner margin broad, nearly flat, radially striated.

Dimensions: Holotype length 91, height 85, inflation (both valves) 32 mm.

Type locality: Hampton Microwave Repeater Site, 33 miles east of Madura, latitude 31° 57′ 57″, longitude 127° 34′ 45″.

Material: Holotype (a pair) WAM 69·334, WAM 61-33, GSWA F7052 (fragments of 2 valves).

Distribution: Pleistocene of the Roe Plain, Western Australia.

Miltha lindsayi Ludbrook sp. nov.

pl. 5, figs. 1-7

Shell large, rather thin, chalky, gently convex, slightly inequilateral, posterior margin obliquely truncated, anterior and ventral margins rounded; posterior area well developed and marked by a shallow radial sulcus and flexure; umbos small, very slightly incurved and prosogyrous, situated a little to the anterior, lunule deeply impressed and transgressive over the hinge area, ligament deeply sunken below the dorsal margin; surface ornamented with conspicuous concentric lamellae about 1 mm. apart with microscopic concentric threads between them, median radial sulcus not usually present.

Hinge plate relatively narrow and long, curved, with a high posterior cardinal and small anterior cardinal almost obscured by the lunule, resilium area long and narrowly triangular, longitudinally striate and bordered on its lower edge by a slight ridge from which it is inclined backwards from the surface of the hinge plate. Posterior adductor subovate, anterior adductor long, pedal retractor apparently confluent with the anterior adductor; area within the pallial line filled with secondary calcite, divided into more or less triangular areas by a posterior ridge and furrow and a median furrow below which the surface is conspicuously pitted; inner margin wide, obscurely striate towards the pallial line.

Dimensions: Holotype GSSA M2747 length (estimated) 67, height 70, inflation (both valves) 30 mm.; other specimens length from 64 to 74 mm., height 63 to 75 mm.

Type locality: Jervois Punt approach, Tailem Bend, South Australia. The locality has now been covered by road works at the approach to the punt landing; Norwest Bend Formation, Upper Pliocene.

Material: Holotype GSSA M2747 (a pair), paratypes M3205, M3206, and fragments; M3208 fragmentary material from the Hallett Cove Sandstone.

Distribution: Norwest Bend Formation at Tailem Bend; Hallett Cove Sandstone ¾ mile east of Hallett Cove; Dry Creek Sands, where it overlaps with *M. flindersiana*. The Tailem Bend specimens are chalky and fragile. The specimen M303 from the Dry Creek Sands of Hindmarsh Bore is a thick solid shell with the truncated posterior margin and conspicuous ornament of *M. lindsayi*; the posterior adductor is more elongate and the hinge plate wider than in the more fragile forms of the species.

The species is named in honour of J. M. Lindsay, Assistant Senior Palaeontologist of the Geological Survey of South Australia, who collected the type material.

Miltha nullarborensis Ludbrook sp. nov.

pl. 4, figs. 3-6

The species is known only from external and internal moulds and casts.

Shell small for the genus, subcircular, only moderately compressed, slightly inequilateral, longer than high, posterior area well developed, defined by a prominent radial sulcus and flexure, umbo small, prosogyrous, lunule small, deeply impressed, and tending to encroach on the anterior cardinal, ligament sunken

below the dorsal margin; ornament of evenly spaced, fine, concentric lamellae about 1 mm. apart with microscopic radial threads between.

Hinge of moderate width with a strong anterior cardinal and a long narrow posterior cardinal; posterior adductor roundly quadrate, anterior adductor long and running parallel to the pallial line, pedal retractor impression a small deep pit just above the anterior adductor; radial ridges and furrows rather poorly developed; inner margin broad, smooth.

Dimensions: Holotype GSWA F6871/1 length 49, height 48 mm.

Type locality: "140-mile quarry", 6 miles southwest of Forrest, Western Australia; Nullarbor Limestone.

Material: 8 specimens, mostly internal casts and external moulds in hard limestone from "140-mile quarry" and Naretha, Western Australia; Watson Quarry and Lake Yarle, South Australia.

Distribution: Nullarbor Limestone (Lower Miocene) of the Eucla Basin.

REFERENCES

Arnold, R., 1909. Paleontology of the Coalinga District, Fresno and Kings Counties, California. *Bull. U.S. geol. Surv.*, **396**, 1-173.

Bennett, Isobel, and Pope, Elizabeth C., 1953. Intertidal zonation of the exposed rocky shores of Victoria, together with a re-arrangement of the biogeographical provinces of temperate Australian shores. *Aust. J. Mar. Freshw. Res.*, **4**, 105-159.

Beu, A. G., 1966. Sea temperatures in New Zealand during the Cenozoic Era, as indicated by molluscs. *Trans. R. Soc. N.Z.* **4** (9), 177-187.

Chavan, A., 1938. Essai critique de classification des Lucines. *J. Conch. Paris*, **82** (1), 59-130.

Cotton, B. C., 1947. Some Tertiary fossil molluscs from the Adelaidean Stage (Pliocene) of South Australia. *Rec. S. Aust. Mus.*, **8** (4), 653-670.

Crespin, Irene, 1950. Australian Tertiary microfaunas and their relationships to assemblages elsewhere in the Pacific region. *J. Paleont.*, **24** (4), 421-429.

Dall, W. H., 1903. Contributions to the Tertiary fauna of Florida. *Trans. Wagner free Inst. Sci. Philad.*, III (VI), 1219-1654.

Dall, W. H., 1905. Note on *Lucina* (*Miltha*) *childreni* Gray and on a new species from the Gulf of California. *Nautilus*, **18** (9), 110-112.

Doello-Jurado, M., 1919. Une nouvelle espece de "*Miltha*" du Tertiaire de l'Argentine. *Physis, B. Aires*, IV (18), 558-562.

Dorman, F. H., 1966. Australian Tertiary Paleotemperatures. *J. Geol.*, 74 (1), 49-61.

Finlay, H. J., and Marwick, J., 1937. The Wangaloan and associated faunas of the Kaitangata-Green Island Subdivision. *Paleont. Bull. Wellington*, **15**, 1-140.

Fleming, C. A., 1966. Marwick's Illustrations of New Zealand Shells, with a checklist of New Zealand Cenozoic Mollusc. *Bull. N.Z. Dep. scient. ind. Res.*, **173**, 1-456.

Gardner, J., 1926. The molluscan fauna of the Alum Bluff Group of Florida. *Prof. Pap. U.S. geol. Surv.*, 142-C, Part III, Lucinacea, Leptonacea, Cardiacea.

Grant, U. S., and Gale, H. R., 1931. Catalogue of the marine Pliocene and Pleistocene Mollusca of California. *Mem. S. Diego Soc. nat. Hist.*, 1, 1-1036.

Keen, A. M., 1958. Sea shells of tropical West America. *Stanford University Press.*

Lamy, E., 1920. Revision des Lucinacea vivants du Museum d'Histoire naturelle de Paris. *J. Conch. Paris*, LXV (1), 71-122.

Ludbrook, N. H., 1954. The molluscan fauna of the Pliocene strata underlying the Adelaide Plains. Part I. *Trans. R. Soc. S. Aust.*, **77**, 42-64.

Ludbrook, N. H., 1955. *ibid.* Part II. *Trans. R. Soc. S. Aust.*, **78**, 18-87.

Ludbrook, N. H., 1959. A widespread Pliocene molluscan fauna with *Anodontia* in South Australia. *Trans. R. Soc. S. Aust.*, **82**, 219-233.

Marshall, P., and Murdoch, R., 1921. Some Tertiary Mollusca, with descriptions of new species. *Trans. N.Z. Inst.* LIII, 77-84.

Marwick, J., 1931. The Tertiary Mollusca of the Gisborne District. *Paleont. Bull. Wellington*, **13**, 1-177.

Reeve, L. A., 1841-2. Conchologia Systematica, or complete system of conchology; in which the Lepades and conchiferous Mollusca are described ..... 2 vols. *London.*

Stewart, R., 1930. Gabb's California Cretaceous and Tertiary Type Lamellibranchs. *Spec. Publs. Acad. nat. Sci. Philad.* **3**, 1-314.

SVERDRUP, H. U., JOHNSON, M. W., and FLEMING, R. H., 1942. The Oceans, their physics, chemistry and general biology. *New York, Prentice-Hall Inc.*
TATE, R., 1890. On the discovery of marine deposits of Pliocene age in Australia. *Trans. R. Soc. S. Aust.*, **13** (2), 172-180.
VOKES, H. E., 1939. Molluscan faunas of the Domengine and Arroyo Hondo Formations of the Californian Eocene. *Ann. N.Y. Acad. Sci.* XXXVIII, 1-246.
WILKINS, G. L., 1957. The Cracherode Shell Collection. *Bull. Br. Mus. nat. Hist.* Historical series, 1 (4).
WILKINS, R. W. T., 1962. *Miltha* in the south-eastern Australian *J. malac. Soc. Aust.*, **6**, 43-49.
WOODRING, W. P., BRAMLETTE, M. N., and KEW, W. S. W., 1946. Geology and Paleontology of Palos Verdes Hills, California. *Prof. Pap. U.S. geol. Surv.*, 207.
WOODS, N. H., 1931. Pelecypoda from the Abattoirs Bore, including twelve new species. *Trans. R. Soc. S. Aust.*, **55**, 147-151.

EXPLANATION OF PLATES

All figures natural size

PLATE 1

Miltha demanti Wilkins

1,4. GSSA M1340, left valve, Loxton 5-10 feet (1·52-3·04 m.) below bed of River Murray; Bookpurnong Beds, Lower Pliocene.
2. NMV P22803, left valve, dump of excavations for sewerage tunnel 40 feet (12·11 m.) from surface, Beech and Wright Streets, Bentleigh, Victoria; Black Rock Sands, Cheltenhamian.
3. NMV P22808, right valve, same locality.
5. GSSA M2274b, right valve, A.O.G. Loxton No. 1 Well, 100-105 feet (30·48-32·00 m.); Bookpurnong Beds.
6. GSSA M2762, right valve, same locality.

PLATE 2

Miltha flindersiana Singleton and Woods

1. GSSA M305, Cowandilla Bore 470-485 feet (143·25-147·8 m.); Dry Creek Sands, Upper Pliocene.
2. NMV P26887, left valve, dam on Hills Block 52, Furneaux Estate Section B, 1·0 mile NNE of The Dutchman, Flinders Island; Cameron Inlet Formation, Upper Pliocene.
3-5. NMV P22886; 3, 5, right valve; 4, left valve; dam on Block 47, Furneaux Estate, Section B, Flinders Island; Cameron Inlet Formation, Upper Pliocene.
6. GSSA M2227, right valve, Kooyonga Golf Club Bore 15/62, 502 feet (153 m.); Dry Creek Sands, Upper Pliocene.

PLATE 3

Miltha hamptonensis Ludbrook sp. nov.

1. Holotype WAM 69·334 right valve of a pair of valves, Hampton Microwave Repeater Site, 33 miles east of Madura, Western Australia; Pleistocene.
2,3. Paratype, juvenile, WAM 61·33, 20 miles east of Madura; Pleistocene.

PLATE 4

1,2. *Miltha hamptonensis* Ludbrook sp. nov.
Holotype WAM 69·334 internal views; 1, left valve; 2, right valve, Hampton Microwave Repeater Site, 33 miles east of Madura; Pleistocene.
3-6. *Miltha nullarborensis* Ludbrook sp. nov.
3, paratype GSSA 3199a, Watson Quarry, South Australia, Nullarbor Limestone Lower Miocene; 4, paratype GSSA 3198a Naretha, Western Australia, Nullarbor Limestone; 5, holotype GSWA F6871/1 "140-mile quarry". 6 miles southwest of Forrest, Western Australia, Nullarbor Limestone; 6, paratype GSSA 3199b, Watson Quarry.

PLATE 5

Miltha lindsayi Ludbrook sp. nov.

1. Holotype (a pair) GSSA M2747, Norwest Bend Formation, Tailem Bend, South Australia; Upper Pliocene.
2,3. Paratype GSSA M3205, right valve, Tailem Bend.
4,5. Paratype GSSA M303, right valve, Hindmarsh Bore 450-487 feet (137-148 m.); Dry Creek Sands.
6,7. Paratype GSSA M304, left valve, juvenile, Bore 20 Woodville South; Dry Creek Sands.